

Ohio Agricultural Experiment Station

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SOIL TREATMENT FOR THE FORCINGHOUSE. THE CONTROL OF ROSETTE (*Rhizoctonia*) IN LETTUCE AND TOMATOES AND OF NEMATODES IN CROPS GROWN UNDER GLASS.

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The forcinghouse industry of Ohio is a large one, and is now rapidly increasing; in it large investments of capital have been made and profitable returns have heretofore been secured.

As in other plant industries the growers of lettuce, cucumbers and tomatoes under glass, encounter progressive difficulties. These include soil infesting organisms, such as the soil fungi, *Rhizoctonia*, *Botrytis*, etc., as well as nematodes or eelworms, *Heterodera* sp. The *Rhizoctonia* of lettuce attacks the stems of seedlings, causing definite areas of disease and a certain damping off of the young plants. Upon older plants the disease usually shows in failure of the stem to elongate and a rosette development of the leaves of this unlengthened axis. These effects are shown in the figures which are of Grand Rapids variety; of these Fig. 2 was produced by inoculation with pure culture.

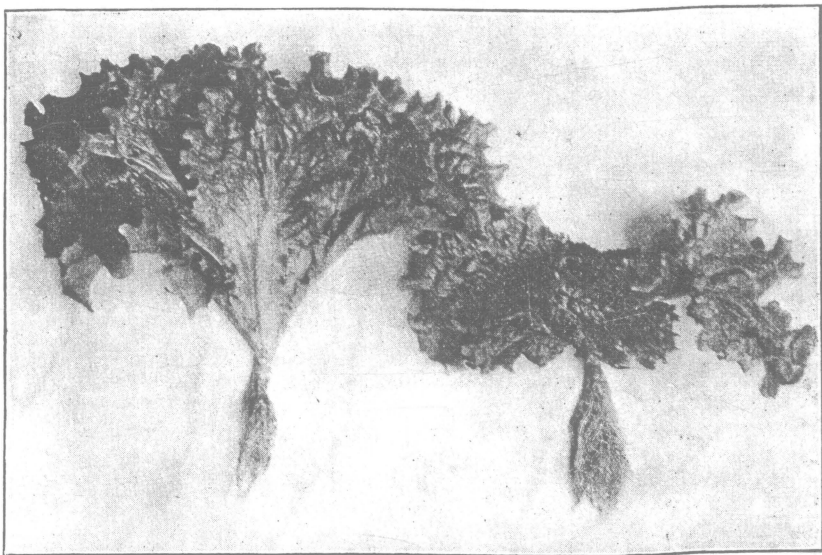


FIGURE 2. Showing on left healthy and on right diseased lettuce plant with "rosette" effects produced by inoculation with pure culture of *Rhizoctonia*. (From culture and photograph by J. M. Van Hook.)

The injury and shortening of crops become most evident during the mid-winter period, when light and temperature conditions are least favorable.

The *Rhizoctonia* or rosette of tomatoes has a similar history on young plants to that on lettuce; upon older plants there is diminished size and clustering of leaflets, usually with diminished fruitfulness.

The nematodes and lettuce drop have been illustrated in Bulletin 73.

There are other soil diseases. No mention is here made of the strictly leaf parasitic troubles, of which there are many, the present discussion being limited to soil infesting organisms.

GREENHOUSE SOILS AND THEIR TREATMENT FROM YEAR TO YEAR.

While in the beginning of the industry vegetable growers practiced changing the soil frequently, this practice has become less general. The custom may at present be described as that of continuous use of the soil first chosen for filling the greenhouse beds, with semiannual additions of rotted manure and mineral fertilizers and with only occasional change or other addition. The initial soils vary with the location of the forcinghouse plant, although the striking development of the forcinghouse industry near Lake Erie, especially in the cities of Toledo, Cleveland and Ashtabula, has resulted in the employment of similar types of soil. This similarity does not extend in like measure to other portions of the state. At Ashtabula, especially, the soil is that from the old lake beach deposits, and is very sandy in character. The extreme of sandy character is not so marked at the other points, although the silicious content of all these soils seems to be high. In the extreme condition, not only is the silicious matter high but the lime compounds are relatively deficient. Given such a soil, its continuous cultivation with the addition of large amounts of rotted manure may result in well marked lime deficiencies. Whether the soil be of this extreme type or not, from determinations made through the kindness of the Station chemist, the lime requirement of soils used many times over seems to increase very decidedly. It is inferred that the prolonged use of soil tends to increase the need of lime.

CERTAIN FUNGI FLOURISH BETTER IN THESE ACID SOILS.

Along with the increased lime requirement of the soils repeatedly employed in greenhouses, comes the matter of soil infesting fungi. Of these the most troublesome sort is the sterile fungus *Rhizoctonia*. This fungus develops with great luxuriance upon an acid medium, while apparently its growth is less rapid in a neutral,

at least in an alkaline medium. There seems to be some connection, therefore, between this increasing lime requirement of greenhouse soils and the increased damage from this soil infesting fungus, *Rhizoctonia*. This brief statement is made since it leads to the suggestion of lime applications, or the equivalent of wood ashes, to such soils. The application of wood ashes, of burnt lime, or of ground raw limestone, would furnish the corrective for the increasing lime need of old greenhouse soils. Some experiments have been made during the last winter and spring which tend to support the correctness of such treatment. From these we conclude that not only is the application of bases favorable to the growth of lettuce, but also to that of tomatoes in a forcinghouse

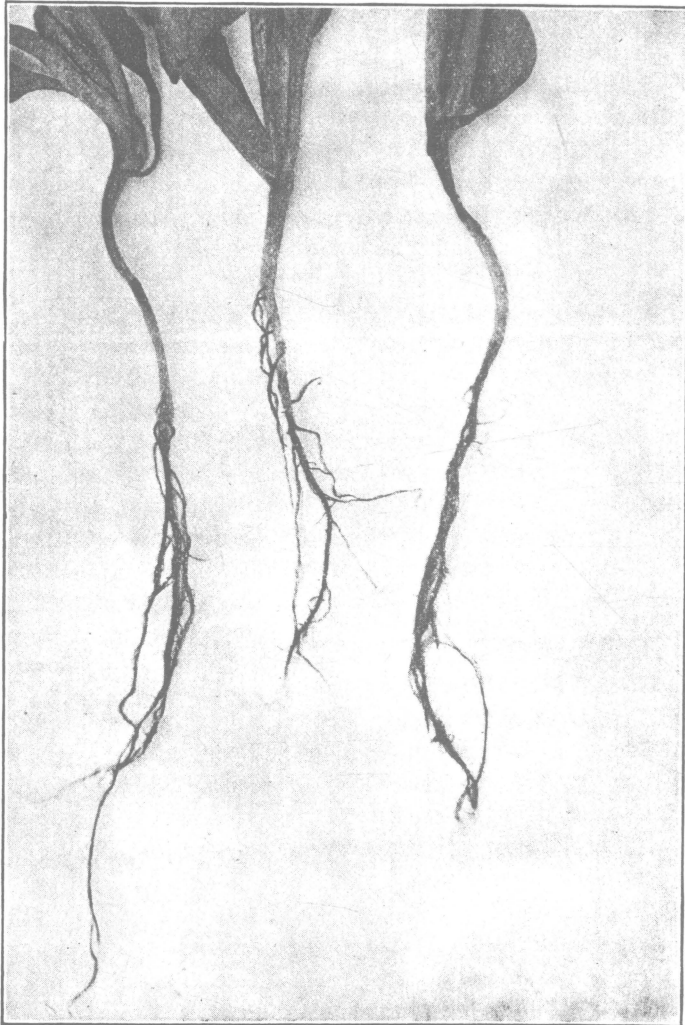


FIGURE 1. Seedling lettuce plants showing lesions caused by the attacks of *Rhizoctonia*. Much reduced. (From photograph by J. M. Van Hook).

soil. The applications may be as great as 5 to 7 lbs. of lime per 100 square feet of surface and twice this amount of raw limestone. Even with this correction, while favorable, further soil treatment as required to destroy the soil parasites.

SOIL STERILIZATION—FORMALIN *versus* STEAM.

However well adapted the greenhouse soil may be in its reaction and its content of plant food, soil infesting parasites must be destroyed. Handling of the soil and piling it out of doors as in the old practice to admit of freezing, in our climate, might supply the needed germ destruction. With the continuous use of the same soil, however, germicides are called for. Of these germicidal treatments, steaming has been in use for many years. For a little more than three years past the writer has been experimenting with aqueous solutions of formalin or 40 per cent, formaldehyde, for the destruction of *Rhizoctonia* and other fungi in the soil. The formaldehyde or formalin treatment and the steaming appear to be of about equal efficiency. Somewhat irregular results have been obtained from the formalin treatment upon soils where lettuce rot has been severe. Possibly a somewhat increased strength over that employed in the past, which was 1 to 1½ pounds formalin in 50 gallons of water, may give more satisfactory results. The formalin treatment, however, is believed not to be effective for nematodes; exact determinations of the effect upon nematodes remain to be made. Where the encysted nematodes, or eelworms (*Heterodera*) infest the soil, steaming appears to be the only effective treatment at present known, and since the injuries from eelworms are especially conspicuous upon cucumbers, the greenhouses devoted to cucumbers are liable to become infested with these nematodes. The steaming is also fully effective in the prevention of lettuce rot. The choice of method for soil sterilization will then rest upon the character of the soil parasites and the convenience or preference of the grower.

FORMALIN TREATMENT OF THE SOIL.

Soils to be treated by any method should be prepared as for use, by additions of manure, etc., so that the latter is incorporated before treatment. The soil being spaded, or plowed, it is ready for treatment, provided, however, it is in what we may call good tilth as to moisture content. In case the soil is too much dried out there will be an unequal absorption of liquid by the soil. An especially fitting time for such treatment will be just at the end of forcing-house season, when the crop is removed and the soil is still fairly well moistened. At such time it is recommended to treat with formalin at the rate of one gallon of the preparation to each square foot of the surface. The strength recommended is 1 to 2,000—2 pints,

or pounds of formalin in 50 gallons of water. The application may be made by any sprinkling device, such as spray pump, sprinkling can, or in the case of large houses, through the Skinner watering pipes. It will usually be advisable to apply the liquid at intervals a few hours apart, until the whole amount has been taken up by the soil. After such a heavy "wetting down" the soil needs to be without planting for about two weeks, with stirring after a few days. If young seedlings are set in such soil too soon they will perish, owing to the presence of the formalin. It is believed that this strength of formalin treatment will be entirely effective against *Rhizoctonia* upon either lettuce or tomatoes, and it is expected to be satisfactory in checking lettuce rot. Some difficulty attends the heavy "wetting down" of the beds between crops in midwinter. For this treatment 1½ pints to 50 gallons was the strength employed last winter. This gave entirely satisfactory results with the *Rhizoctonia*, but did not, as before stated, with the lettuce rot, *Botrytis*.

In continuous lettuce growing some soil treatment has been shown to be essential, and this treatment should begin with the plant beds in which the seed is sown, and extend, especially, throughout the house or soil in which the young plants are developing. Final success equally demands sterilization of the plant beds where they are brought to maturity. Such treatment has notably increased the crop of certain infested houses the past winter and spring.

STEAMING THE SOIL.

As was stated in Bulletin 73, steaming the soil is an effective means of soil sterilization. This steaming is attended with certain difficulties and in silty, or heavy soils, certain soil dangers as well. Essentially, it consists in burying a series of pipes in the soil at intervals, covering the surface of the beds and passing live steam in sufficient volume into the pipes. The earlier experiments were nearly all with high pressure steam, but more recent trials with steam pressure as low as four pounds show that the treatment may be made fully as effective with low pressure boilers. It follows, therefore, that hot water heating plants may be employed for soil sterilization. In greenhouses provided with steam heating, we can treat with high or low pressure at will. The success of the steaming will depend upon the amount of steam in the pipes and the length of time the treatment continues since the soil temperature will determine the result. It is as essential, or really more essential, that the soil should be in a condition of good tilth before the steam-

ing is undertaken, than in the matter of formalin treatment. If soil is permitted to become dry, it must be treated to water and brought back into proper condition before steaming is undertaken, or uneven results may be expected. The following detailed descriptions are given of some methods employed by different growers in steaming:

DETAILS OF BED STEAMING.

The steaming method seems to consist, at its best, in a system or set of perforated pipes, with crosshead and boiler connection. These pipes are connected and buried in the soil of the bed, either with or without partial banking up of the soil; the surface of the bed is then covered with canvas and the steam passed into the system for such period as is required to heat the soil to the necessary temperature. This temperature for best results is 180° to 212° Fahr., maintained for a period of an hour or more. The time required to attain this temperature will vary with the boiler area, pressure and other steam and soil factors.

This bed method has replaced the former one of box with steam pipes into which the soil was transferred.

The length of pipes of the system will be adapted to the beds, being, say, one-half or one-third the total length of large beds. The size of the perforations in the pipes are apportioned to the area of the supply pipe.

Mr. R. W. Griswold, Jr., of Ashtabula, O., employs 4 bed pipes $1\frac{1}{2}$ in. in diameter and 80 feet long; in these $\frac{1}{8}$ inch holes are made in straight line, 1 foot apart.

The head pipe and main to boiler are 2 in. in diameter, the boiler 100 H. P. The beds are 5 feet wide and in these the pipes are evenly distributed by trenching. He starts at 80 lbs. pressure for 1 hour and then drops to 60 lbs.

On low pressure boiler, Mr. B. H. Thorne, of Wooster, O., uses 4 pipes, $1\frac{1}{4}$ in. in diameter, in 10 foot sections with $\frac{1}{4}$ in. holes 4 in. apart, $1\frac{1}{2}$ in. head, with pipes 10 in. apart. These pipes are trenched in about $\frac{1}{2}$ the width of bed, this area banked up at sides with boards and remainder of soil thrown upon it, thus increasing the depth before covering and turning on steam. In this manner about 4 to 5 hours are required to steam soil as above, with about 6 to 7 pounds pressure from hot water heating boilers; this soil is left over night. Owing to great size of the holes in pipes, blowing out often occurs and even heating is at times difficult to secure. Smaller holes in bed pipes would serve better.

THE COMPARATIVE ADVANTAGES AND DISADVANTAGES OF
FORMALIN AND STEAMING.

The cost of the formalin treatment consists in the cost of the chemical and the labor and in the winter, time loss of houses. The cost of the steaming consists in the investment in pipe to be buried in the beds, and the fuel and the labor and in the same time loss. In very hot weather the formalin method would be less objectionable on account of heat. The same objection will not hold in the winter time. Mr. B. H. Thorne, Wooster, has had several years experience with formalin, and one year's experience with steaming, and finds the cost approximately the same. The steaming method is the better, as before stated, to kill out the nemadoes. The worst disadvantage of the steaming—much worse than the high temperature in summer—is the change brought about in the soil texture. Certain silty soils may become so altered that extreme care is needed to avoid over-watering and water-logging after steaming. The newly steamed soil of this type is easily over-watered and extreme care is required in the applications of water to silty or heavy soils until these have become well dried out or some time has elapsed after steaming, by which the water relations again become normal. An example of this danger has been studied, in which, the over-watered lettuce upon freshly steamed soil never attained satisfactory development. The succeeding crop, however, was entirely up to expectations. Some trials made with formalin in badly infested plant houses and greenhouses have resulted in heavy lettuce plants and increased yields where the formalin treatment has been employed. Greenhouse men who have to contend with these soil diseases are urged to apply one or the other method of sterilization, as it is believed that this will prove profitable. This department has been at work for several years upon these troubles, and issues this circular as a preliminary recommendation. After further experiments and laboratory studies of the diseases it is hoped to embody the final results in bulletin form.